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SOIL SERIES SURVEY OF SELECTED STUDY AREAS IN THAILAND

SUMMARY REPORT

by

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FOREWORD

This study constitutes a portion of the Mobility Environmental Research Study (MERS), sponsored by the Office, Secretary of Defense, Advanced Research Projects Agency (ARPA), Directorate of Remote Area Conflict, for which the U.S. Army Engineer Waterways Experiment Station (WES) is the prime contractor and the U.S. Army Material Command (AMC) is the service agent. The broad mission of Project MERS is to determine the effects of the various features of the physical environment on the performance of cross - country ground contact vehicles and to provide therefrom data which can be used to improve both the design and employment of such vehicles. A condition of the project is that the data be interpretable in terms of vehicle requirements for Southeast Asia. The funds employed for this study were allocated to WES through AMC under ARPA Order No. 400.

The work for this study was performed under an agreement between the Soil Survey Division, Land Development Department of the Royal Thai Government, and the WES Thailand Detachment. This report was prepared by Dr. Frank R. Moormann, FAO Soil Specialist, with the assistance of Messrs. Les Moncharoen and F.J.Dent. Overall technical responsibility for coordinating all MERS pedological soil classification studies, including the specific study described herein, was assigned to Mr. A.C.Orvedal, Chief, World Soil Geography Unit, U.S.Department of Agriculture.

Acknowledgement is made to Prof. Santhad Rojanasoonthon, Kasetsart University, for his assistance in the establishment of the soil legend and the editing of the maps and text of this report.

CONTENTS

SUMMARY

The study reported herein presents a summary of the methods and techniques used in the survey and correlates the various soil series with great soil groups and subgroups and physiographic position. The corresponding taxa of the new USDA soil classification system (1)* were also indicated. A summary is given of the geomorphologic relationships between the various soil series.

For each of the selected study areas, detailed descriptive reports accompanied by soil maps on a scale of 1:50,000 were prepared and included as appendixes A through F to this report. Each appendix includes a general description of natural conditions in the study area as related to soil conditions, as well as a detailed description of the mapping units.

* Numerals in parentheses refer to similarly numbered items in the Literature Cited at the end of this report.

INTRODUCTION

Background

Pedological soil classification and mapping are the most widely accepted means of portraying soil conditions throughout the world. Since this information is useful in interpreting trafficability conditions in remote areas, a logical approach to the Mobility Environmental Research Study (MERS) in Thailand was to exploit available pedological soil information. Much information of a general nature was available from which general pedological soil maps could be made. Furthermore, provisional mapping units suitable for semidetailed surveys were already established for northeastern Thailand and other smaller areas. Thus, when a requirement was established to map the areal distribution of the significant terrain factors of selected areas in Thailand, studies were initiated to classify and map the soils of these areas in terms of the great soil groups and soil series. The study reported herein pertains to the classification and mapping of soils in terms of the soil series or their subdivisions in terms of phases.

Purpose and scope

The objectives of this study were to conduct a semi-detailed pedological soil survey of six primary study areas (Nakhon Sawan, Lop Buri, Chiang Mai, Pran Buri, Khon Kaen, and Chanthaburi) in Thailand and to present by maps (scale 1:50,000) and an accompanying text the soil characteristics of these six areas. Insofar as possible the soils were classified as series, or phases of series, in accordance with the current system for mapping soils in the United States.

The information for this study was obtained by systematic study of soils in the field combined with air-photo interpretation. Limited use was also made of existing information. Available information was studied, revised where necessary, and translated into a common terminology recognized in current international literature. Six areas were surveyed (see fig. 1). The soil survey reports, including maps, are presented in six appendices (A through F). The appropriate appendix identification and approximate area of each study area are given in the following table.

Area No.	Appendix	Name	Approximate Area Sq km	Sq mi
1	A	Nakhon Sawan	2,965	1,145
2	B	Lop Buri	3,802	1,468
3	C	Chiang Mai	3,706	1,431
4	D	Pran Buri	570	220
5	E	Khon Kaen	3,131	1,209
6	F	Chanthaburi	2,870	1,108

SOURCES OF INFORMATION

Thailand

The main source of information on soil classification and distribution prior to this study was the published reports (2,3) and unpublished field notes, reports, and laboratory data of Pendleton. However, most of this information, more than 25 years old, is not in modern soil classification terminology and the available laboratory data are not usable without much precaution and interpretation. The soil units established by Pendleton for his provisional map of the soils and surface rocks of the Kingdom of Siam are identified as Bangkok clay, Korat sandy loam, etc. Rather than being soil series as the names suggest, these units are more nearly on the level of the great soil groups or associations thereof and are strongly biased by actual and/or potential land use. Consequently, only little of this information was useful to the study described herein.

Since 1961 modern soil surveys patterned after the U.S. Department of Agriculture (USDA) systems (1,10) have been conducted in Thailand by the Thai Land Development Department (LDD). However, these surveys cover relatively small areas scattered throughout the country and differ considerably in detail and precision. Reconnaissance surveys are made when a quick appraisal of a potential development area is needed; these surveys are on the great soil group level at a scale of 1:250,000. Detailed reconnaissance surveys are made on a systematic basis (the plan is to survey the entire country), and

work on these surveys is at present concentrated in northeastern Thailand; these surveys are on the series level at a scale of 1:100,000. Semidetailed and detailed surveys are made for specific development areas, irrigation project areas, agricultural experimental stations, etc., as the need arises; these surveys are on the soil series and soil phases level at a scale of 1:50,000 (subdivisions of soil series are commonly used for very detailed work).

LDD soil survey information utilized for this study includes a detailed reconnaissance survey of part of the Chiang Mai study area (4), a semidetailed survey of the northwestern corner of the Lop Buri study area (5), detailed surveys of agricultural experimental stations near Changwat Khon Kaen (Khon Kaen)* (6,7), an unpublished reconnaissance survey map of the province of Khon Kaen, and the great soil group survey of the study areas.** No soil survey information was available for the Nakhon Sawan, Pran Buri, and Chanthaburi study areas.

Other Southeast Asian countries

Most of the soil survey information on other countries of Southeast Asia is not up to the standards of the current work in Thailand. The status of soil information on other Southeast Asia countries is briefly described below.

Malayan Federation (Malaysia). In this country important areas have been surveyed at the soil series level. Some of these surveys were made in the older settled areas (e.g. the northwestern coastal plain in Perak state), but the most recently surveyed areas are in the forested interior of the peninsula. A general soil map of Malaya was published in 1962 (8) in terms of associations of great soil groups.

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* Populated places are spelled in this manner the first time they appear, followed by an abbreviated form in parentheses. Thereafter, only the abbreviated form is used in the text.

** The reports on this study were also published in the series of Soil Survey Reports of the Land Development Department under Nos. 28, 31,35, 38, 41, 43, 44, and 48.

South Viet Nam. A general soil map (scale of 1:1,000,000) of South Viet Nam which uses associations of great soil groups as the basic units (9) and good-quality soil series surveys exist for several small areas of the country.*

Burma. A general "genetic" soil map of Burma has been prepared by a Russian Aid Mission. Although the classification and terminology of this map are not the same as are being currently used in other countries of Southeast Asia, the map appears to be fairly accurate in regard to the delineation of the various soil units.

Cambodia. A rough reconnaissance soil map of Cambodia was prepared by a soil scientist from USDA-AID; however, very little soil classification information of a more detailed nature is available for this country.

Laos. Modern soil classification information on Laos is practically nonexistent.

METHODS AND TECHNIQUES

Units of soil classification and mapping

Most units on the soil maps for the six study areas have been designated as soil series or soil phase, but some map units have been designated as unnamed soils, soil complexes, or soil series associations. Miscellaneous rock types were also delineated.

Soil series. In the survey reported herein, the basic unit of soil classification is the soil series. The soil series is defined (1) as "a collection of soil individuals . . . that, within defined depth limits, are uniform in all soil properties diagnostic for the series." A series is usually named after the province or district in which it was originally identified, but village names and names of hills or of streams are sometimes used. Abbreviations of these names are used on the soil maps and are mnemotechnic, i.e. Kt stands for Korat series, Cm for Chiang Mai, etc.

Soil survey in Thailand is of a rather recent date, and consequently knowledge of diagnostic soil characteristics is as yet frequently insufficient for defining soil series as precisely as in the United States. Furthermore, the detail to which mapping is

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* Partly published by the Ministry of Rural Affairs, South Viet Nam.

carried out in most surveys in Thailand is considerably less than in soil surveys classed as detailed in the United States. In the future when detailed revisions of present surveys are made, certain series presented in this report undoubtedly will have to be separated into two or even three series.

Soil phase. The soil phase, in this study, is a segment of the soil series which differs in one or sometimes two characteristics from the modal or control concept of the series. The basis of the subdivision may be any characteristics of importance for actual or potential human use of the soil. The types of soil phases used in this study are as follows :

a. Topography phase. Usually a high or low topographic position relative to the position considered to be modal for the series.

b. Slope phase. Only used occasionally in this study for soils on colluvial footslopes.

c. Texture phase. Soils that are either more sandy or more clayey in one or all horizons than the modal for the series.

d. Color phase. Only used for soils with a subsoil that is redder than the color considered modal for the series.

e. Drainage phase. Soils whose drainage is somewhat better or poorer than the drainage considered modal for the series.

f. Depth phase. Soils which contain stones, gravel, and/or laterite at some depth but otherwise have characteristics considered modal for the series.

g. Soil reaction phase. Soils that have a pH value in the subsoil that is either considerably above or below the pH value considered modal for the series.

h. Soil salinity phase. Soils that differ from the modal part of a series by being saline or having saline spots in the dry season which disappear in the wet season.

i. Soil humus phase. Soils with a darker, more humiferous surface soil (A1 or Ap horizon) than considered modal for the series. (Several soil phases described in this study are actually "variants" according to the USDA classification.)

Unnamed soils. In most study areas a few soils, unlike any of the soil series, were left as unnamed units. The occurrences of these unnamed soils are too limited at this time to accord them a separate series name and definition. These unnamed soils are indicated on the soil maps by the letter U and a numeral.

Soil series associations. Associations are groupings of two soil series and are indicated on the maps by a symbol, e.g. Ty/Ly (Ty = Tha Yang, Ly = Lat Ya). Associations were used in areas where the detail of survey did not permit the cartographic separation of the two series.

Soil complex. A soil complex as used in this study consists of two or more recognized physiographic or taxonomic units which cannot be individually separated in a detailed soil survey. Complexes identified in this study are : (a) physiographic-slope complex (Sc) and alluvial complex (Ac), (b) taxonomic-unnamed complex (Uc) and Kamphaeng Saen (Ks-c) complex. Subdivisions of the slope comples are made according to the dominant parent rock.

Special characteristics. A few mapping units are indicated by a special letter or symbol. Examples of these units are saline spots which are delineated by an "x" symbol and rock outcrops which are shown by an "⊤" symbol.

Air photos and maps.

Air photos. All mapping work was first performed from air photos. For most of the study areas Army Map Service (AMS) air photos prepared by World Surveys in 1953-54 were used. AMS photos for all but the Chiang Mai study area are at a scale of approximately 1:40,000. The scale of photos in the Chiang Mai study area is approximately 1:55,000. Limited parts of several study areas are covered by air photos at a scale of 1:20,000. During the conduct of this study new air photos at a scale 1:5,000 and 1:15,000 were acquired by contract under the MERS program. However, these photos covered only parts of some study areas and most of the photos became available after the field work had been completed. These new photos were used for the Lop Buri study area and for the northern part of the Pran Buri area. The 1:5,000-scale air photos of Nakhon Sawan were used only for checking certain soil units after the field work had been completed.

The new MERS air photos provided excellent details for interpreting soil conditions, but the AMS photos had to be used with great caution. Changed land use and new roads and waterways made correct field localization and pedological interpretation very difficult. This condition was particularly true in the Chanthaburi study area inland from National Highway No. 6 where such land has been reclaimed and cultivated.

Maps. Base maps used for this survey were series L 708 AMS topographic maps at a scale of 1:50,000. These maps were compiled mainly from the 1953-1954 AMS photos; hence these maps have the same weaknesses in regard to land use and recent topographic features as the AMS photos.

Field studies

Field studies were made in all six areas. Field observations consisted of examination of soils by borings or in pits, roadcuts, and quarries. An average of about 13 observations per square kilometer was made, but the density of observations varied considerably in relation to the terrain. Observation density in large homogeneous areas, e.g. the alluvial areas of the Central Plain, dropped well below the average. Part of the Lop Buri study area was inundated during the period of the survey and was mapped by air-photo interpretation only. Most of the Pran Buri study area was surveyed in much greater detail than the other areas. The density of observations and the detail of mapping was mainly determined by the time allotted for the survey. The resulting soil maps are detailed reconnaissance maps, in the terminology of LDD, but most of the soil map of the Pran Buri study area is considered to be a semi-detailed soil map.

Borings were made by an auger to a maximum depth of 125 cm or to the depth needed to determine the soil series or phase. Some of the borings were numbered and an abbreviated description was made in a field notebook for further reference. In each of the study areas a number of detailed soil descriptions were made. Most of these descriptions were made at MERS soil-moisture test sites, but descriptions were also made of some soils in other areas. Detailed profile descriptions are included with the discussion of the various soil series or phases in the appendices to this report.

Other information gathered during the field survey pertains to vegetation, land use (cropping pattern, yield, etc.), geomorphology and surface geology, hydrography and groundwater. To a large extent the survey reported herein was based on air-photo interpretation.

Mapping procedures

The first step in the mapping process was to delineate the obvious soil and geomorphologic characteristics on the available air photos using air-photo interpretation techniques. Alluvial soils (alluvial plains) and complex soils of the hills (hills and mountains) were delineated in this manner. Also indicated were rice lands, which are easily visible on air-photos and which in most cases belong to a different mapping unit--that for soils not used for growing rice. Numerous termite mounds usually indicate a terrain of some age and hence are helpful of separating the young, undeveloped soils of the alluvial plains from the older soils on terraces. Field checks were made to determine the correct soil conditions of most of the units distinguished by air-photo interpretation. Considerably more field work was required to map those soil series that have similar appearances on air-photos. For example, separating the Ubon and Roi Et soils in the Khon Kaen study area required additional field work.

Soil boundaries, first delineated on the air photos, were transferred to AMS Series L 708 1:50,000-scale topographic maps. In the process of transfer soil boundaries were generalized, minor areas were excluded, and some tentative mapping units were eliminated or combined with other mapping units.

Diagnostic soil characteristics

The soil characteristics used for the description and classification of the soils in this survey are mostly those set forth in the USDA Soil Survey Manual (10) and in "Soil Classification, A Comprehensive System, 7th Approximation" (1). A brief summary of those soil characteristics considered to be diagnostic for the purposes of soil classification and the differences with current USDA usage are discussed in the following paragraphs.

a. Soil horizons. Genetic horizon designations like A, B, and C were used in the descriptions of the mapping units. For general descriptive purposes use was also made of

the terms "surface soil" and "subsoil". Surface soil includes the A horizon (s) up to a maximum depth of approximately 30 cm, and subsoil encompasses the B and C horizons from approximately 30 cm downward. Of special and diagnostic importance for soil surveys in Thailand (and other tropical countries) is the presence of laterite which, while recognized as a separate soil horizon in the USDA literature, is not always treated as a diagnostic characteristic. Layers with a dominance of laterite (plinthite) were treated in this study as a diagnostic subsurface horizon.

b. Soil color. Determination of colors was made according to the Munsell soil color charts. In some descriptions terms such as brownish or reddish were used to give a larger variety of colors than given in the Munsell soil color charts.

c. Soil texture. Textural classes used are in accordance with the USDA Soil Survey Manual (10). As only a few laboratory checks on field determinations of texture were available, most of the textural classes indicated in the descriptions of the mapping units are approximations; a soil series indicated as having sandy loam texture may well have a loam or silt loam texture. For this reason frequent use was made of general groupings of soil texture classes, i.e. sandy, loamy, and clayey. Little attention was given to differences in size distribution of the sand fraction though it is known that the sand fractions in the coastal areas (Chanthaburi, Pran Buri)are commonly considerably coarser than in the interior (e.g. Khon Kaen). Coarse fragments were indicated by the terms gravelly or stony according to size with little emphasis on the mineralogy of the coarse fragment. However, the presence of hardened laterite concretions was usually indicated separately.

d. Soil structure. Soil structure, although an important soil characteristic, is not usually treated as a diagnostic characteristic in this study since it is difficult to determine by auger boring. The granular surface structure of Grumusols (e.g. Lop Buri series), however, is easily observable and is thus used as a diagnostic characteristic for the series belonging to this great soil group.

e. Soil reaction. Soil reaction is an important diagnostic characteristic for soils in Thailand; hence the pH is usually measured in the surface soil and the subsoil by the Truog Hellige indicator. The terms used for ranges in pH are those of the USDA, even though they are not entirely satisfactory from a practical soil management point of view in Thailand. Relatively few soils in Thailand are neutral or alkaline; the presence of free lime is however used commonly as a diagnostic soil characteristic.

f. Drainage. Soil drainage, as indicated by the presence or absence of a gleyed horizon, is extremely important at the soil series and soil phase level of classification. Although drainage classes used in this study are commonly the same as those described in the USDA Soil Survey Manual, a certain grouping was often applied in the classification of soil in Thailand. Groupings of soils which are free of mottling in the profile or which have mottling beginning in the subsoil comprose the classes of moderately well, well, somewhat excessively, and excessively drained soils; soils with mottling starting immediately below the surface layer are imperfectly or somewhat poorly drained soils; and soils with mottling starting in the surface layers with reduced layers at some depth in the profile are poorly and very poorly drained soils. Altered drainage conditions are common under rice cultivation where water is impounded on the land during the wet season. Such soils, if already not mottled, become mottled in the surface layers (inverted gley), but the colors of the subsoil related to the natural drainage conditions prior to rice production tend to persist.

It should be noted that the strong seasonal rainfall imposes an extreme influence on soil moisture conditions in Thailand. Thus, soils with the morphologic characteristics of poor drainage (gleying and mottling throughout the profile) which are frequently inundated under rice cultivation for several months may dry to a considerable depth in the dry season. Such soils, seasonal wet soils, are commonly too dry for any crop production for periods of from four to six months unless irrigated.

Mottling in certain soils of highest rainfall areas, e.g. near Chanthaburi, is not necessarily always a sign of retarded drainage. Strong mottling is prominent in weathering parent rocks, especially shales, under high rainfall conditions. Such a mottled material is referred to as "mottled clay".

g. Organic matter. Organic matter content of most soils in Thailand is low, but soils with considerable organic matter, as expressed by dark colors in the surface layers, do occur. Most soils high in organic matter are distinguished from other soils at the soil series level, but a few soils are treated as phases.

h. Soil salinity. Only such salinity which prevents the use of the soils for normal cultivation is used as a diagnostic characteristic. In northeastern Thailand low-lying soils may be strongly saline during the dry season whereas the salinity may be negligible in the wet season when the soils are inundated for rice growing. Where possible, soils with a variable salt content are indicated by a separate phase.

i. Other diagnostic soil characteristics. The presence of catclay (11) is used as a characterist' for classification in the areas of acid sulfate soils (Lop Buri, Chanthaburi, Pran Buri study areas). The presence or absence of mica in the soils of the river levees is a series-determining characteristic. Slickensides, deep cracking , and gilgai relief are diagnostic for series belonging to the Grumusol great soil group.

SOIL CORRELATION

In Thailand correlation of soil at the series level as well as the placement of series into classes of higher categories (soil family, great soil group, order) is not very far advanced. First, knowledge of the soils in the field is of recent date and, as yet, far from complete. Second, specific analytical data necessary for comparing soils of different areas and for grouping soils into families, great soil groups, etc., are mostly incomplete or even not available. Nevertheless, because of the importance of soil correlation, it has been carried out ad the work progressed. Hence, with very few exceptions, like soils are called by the same series names in all study areas.

The classification of soil series into great soil groups is given in table 1. Certain relationships amoung soil series of various regions are easily understood. For instance, the San Pa Tong Series (Sp) of northern Thailand, the Korat series (Kt) of northeastern Thailand, and the Sattahip series (Sh) of the east and west coast of the Gulf of Thailand are clearly related. These series are all Gray Podzolic soils formed on terrace materials, usually medium textured, with a more or less free drainage. Other relationships among soil series in the various areas exist but are much more difficult to define because of a lack of precise field and analytical data. Thus, some of the correlations set forth in table 1 are subject to change as more precise data become available.

In table 1, the series are classified into great soil groups as recognized in Thailand (12) and in Southeast Asia (13). Subdivisions are indicated for some of the great soil groups; these subdivisions, while useful in Thailand, are not commonly recognized in soil series literature. The classification of soil series according to the new USDA classification (1) also is given in table 1. The range in characteristics of a few soil series is such that part of a series may belong in one great soil group and part in another; this condition is indicated where known in remarks column of table 1.

PHYSIOGRAPHY OF THE SOIL SERIES

Landform by itself is not necessarily a basis for differentiating between soil series and other soil mapping units. Yet, most mapping units have a narrow range in landform because differences in landform are commonly co-variant with differentiating soil characteristics, e.g. parent material, texture, drainage. Because of this relationship and also because landform is an important factor in air photo interpretation, much attention has been given in this study to landforms.

Landforms in the wet-dry monsoon climate of Thailand are usually rather easy to distinguish. Quite commonly the transition between the hilly landscapes and the aggradation landscapes of terraces and alluvial plains is sharp and easily visible

in the field. Only in the wet extreme southeast and south of the country do considerable areas of low rolling foothills occur, and here the distinction between terraces and structural hills is more difficult to observe. Rock-cut or strath terraces (peneplains) in the various areas are usually also an easily recognizable physiographic element.

Although the various landforms can be rather easily distinguished, the correlation of geologic ages of the materials that make up the various formations often proves difficult. Three terrace levels can be readily distinguished in northeastern Thailand; in other parts of Thailand, however, such terrace levels are less distinct. Age correlation, especially of the higher (older) terrace levels, is difficult, particularly if one tries to correlate marine terraces of coastal Thailand with river terraces of the inland.

It should be emphasized that very little pertinent information on the physiography of Thailand was at hand, and most of the information used was gathered during this study. Hence, many of the data set forth in this study are tentative. A summary of the physiography of the various soil series distinguished in this study is given in table 2.

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II : The Manorom Tract.

51. Interim Reports, Report No. 38
IV : Chanthaburi Study Area.

52. Chao Phya Irrigation Project, Report No. 39
III : The Boromdhart Tract.

53. Report on the Soil Survey in the Khok Kratiam Tract, Report No. 40

54. Interim Reports, Report No. 41
V : Hat Yai Study Area.

55. Chemical and Mineralogical Study of Subsurface Horizons of Chiang Mai, Report No. 42

56. Interim Reports, Report No. 43
VI : Nakhon Sawan Study Area.

57. Interim Reports, Report No. 44
VII : Lop Buri Study Area.

58. Report on the Soil Survey in the Phet Buri Irrigation Tract, Report No. 45

TABLE

GREAT SOIL GROUP	SUBDIVISION OF GREAT SOIL GROUP	7th APPROXIMATION CLASSIFICATIO
ALLUVIAL SOILS	NOT OR MODERATELY HYDROMORPHIC	UDENT (USTENT?)
	HYDROMORPHIC, NOT ACID AND/OR SALINE	HAPLAQUENT
	HYDROMORPHIC, ACID, NOT SALINE (Acid Sulphate Soils)	HAPLAQUENT (a separate great group may be required)
	HYDROMORPHIC, SALINE	HAPLAQUENT and HYDRAQUENT
REGOSOLS	REGOSOLS ON SAND	PSAMMENTS, PSAMMUSTENTS, some PSAMMAQUENTS
GRUMUSOLS	HYDROMORPHIC	GRUMAQUERT
RENDZINAS		RENDOLL
HUMIC GLEY SOILS		AQUOLL
SOLONETZ SOILS	SOLODIZED	NATRAQUALF
LOW-HUMIC GLEY SOILS	USUALLY WITH HIGH BASE SATURATION	OCHRAQUALF
	USUALLY WITH LOW BASE SATURATION AND/OR LOW C.E.C OF THE CLAY FRACTION; NO LATERITE AT < 50 cm	OCHRAQUULT; partly OCHAQUALF
	USUALLY WITH LOW BASE SATURATION AND/OR LOW C.E.C OF THE CLAY FRACTION LATERITE AT < 50 cm.	PLINTAQUULT
NONCALCIC BROWN SOILS		ULTUSTALF ; possibly some TYPUSTAL
RED BROWN EARTHS		ULTUSTALF and RHODUSTALF
REDDISH-BROWN LATERITIC SOILS		RHODOCHRULT
RED YELLOW PODZOLIC SOILS	NO LATERITE AT < 50 cm.	TYPOCHRULT, possibly partly ULTUSTAL
	LATERITE AT < 50 cm.	PLINTOCHRULT, possibly partly ULTUST
GRAY PODZOLIC SOILS		TYPOCHRULT and ULTUSTALF (a separ great group is required)
REDDISH BROWN LATOSOLS		UDOX ?
RED-YELLOW LATOSOLS		USTOX ?

CLASSIFICATION OF SOIL SERIES INTO G

STUDY AREAS				
A. Nakhon Sawan	B. Lop Buri	C. Chiang Mai	D. Pran Buri	E. Khon Kaen
Tha Muang (Tm) Sapphaya (Sa)	Tha Muang (Tm) Sapphaya (Sa)	Tha Muang (Tm) Sapphaya (Sa)		Chiang Mai (Cm)
Chainat (Ca) Rat Buri (Rb) Yang Pong (Yp) Sara Buri (Sb)	Chainat (Ca) Rat Buri (Rb) Phimai (Pm) Sara Buri (Sb) Bang Khen (Bn)	Rat Buri (Rb) Phimai (Pm) Kalasin (Kn)	Bangkok (Bk) Samut Prakan (Sm) Bang Lamung (Lm)	Rat Buri (Rb) Phimai (Pm) Si Thon (St) Kalasin (Kn)
	Rangsit (Rs) Ongkarak (Ok)		Ongkarak (Ok) Tha Khwang (Tg) Sam Roi Yot (Sy)	
			Tha Chin (Tc) Cha-Am (Ca)	
			Hua Hin (Hh)	Nam Phong (Ng)
Boraphet (Bo) Lop Buri (Lb)	Khok Krathiam (Kk) Chong Kae (Ck) Ban Mi (Bm) Lop Buri (Lb)			
Takli (Tk)	Takli (Tk)			
Tha Tako (To)	Tha Tako (To) Bang Len (Bl)	Tha Tako (To) Mae Khan (Mk)		
			Nang Kae (Nk)	
Phet Buri (Pb) Nakhon Pathom (Np) Krok Phra (Kp)	Nakhon Pathom (Np) Hin Khong (Hk)	Hang Dong (Hd)	Nakhon Pathom (Np)	
Chum Saeng (Cs) Manorom (Mn) Ubon (Ub) Lampang (Lp)	Manorom (Mn)	Lampang (Lp)	Chon Buri (Cb)	Roi Et (Re) Ubon (Ub) Udon (Ud)
Sakon (Sk)	Phan (Pn) Sakon (Sk)	Sakon (Sk)		Phan (Pn)
Kampaeng Saen (Ks)			Pran Buri (Pr)	
Pak Chong (Pc)	Pak Chong (Pc)	Pak Chong (Pc)	Pak Chong (Pc)	
Nakhon Sawan (Ns) Li (Li)		Nakhon Sawan (Ns) Li (Li) Mae [illegible] (Mp)	Nakhon Sawan (Ns)	
Lat Ya (Ly) Tha Yang (Ty)	Tha Yang (Ty)	Lat Ya (Ly) Tha Yang (Ty) Mae Rim (Mr)	Lat Ya (Ly) Tha Yang (Ty)	
	Phan Phi Say (Pp)	Chumpae (Cp) Phan Phi Say (Pp)		Phan Phi Say (Pp)
San Pa Tong (Sp)	Sattahip (Sh)	San Pa Tong (Sp)	[illegible] (Sh)	Korat (Kt) Yang Talat (Yt)
			Sriracha (Sr)	Yasothon (Yt)

GREAT SOIL GROUPS

	F. Chantaburi	Remarks
a)		Tha Muang and Chiang Mai series are closely related The Sapphaya series is transitional to hydromorphic Alluvial soils (Aquents)
)	Ban Khai (Bk) Phimai (Pm) Samut Prakan (Sm) Bang Lamung (Lm)	Part of the Yang Pong and Kalasin soils are Hydraquents Part of the Bang Lan ung suils are Psammaquents Part of the Phimai soils may be Humic Gley Soils (Aquolls) The SaraBuri series is transitional to Low-Humic Gley soils (Aqualfs) Bang Khen soils may be Humic Gley soils (Aqualfs)
	Ongkarak (Ok) Tha Khwang (Tq)	The Ongkarak series in the Pran Buri and Chantaburi study areas includes Rangsit soils. Part of the Sam Roi Yot series soils are Low Humic Gley soils (Aqualfs)
	Tha Chin (Tc) Cha-Am (Ca)	Cha-Am series soils are also actual or potential Acid Sulphate soils
g)	Hua Hin (Hh) Rayong (Ry) Pattalung (Pt) Phatthaya (Py)	Nam Phong and Phatthaya soils may be minimal Gray Podzolic soils (Typochrults)
		Part of the Boraphet, Khok Krathiam and Ban Mi series soils are Humic Gley soils (Aquolls) Chong Kae series soils may be transitional to Low-Humic Gley soils (Aqualfs)
		Tha Takli series includes Brown Forest soils (Ochrepts)
		All series are transitional to Alluvial soils (Aquents) Part of the Bang Len series soils may be Grumusols (Aquerts)
		Tha Phet Buri series is transitional to Noncalcic Brown soils (Typustalfs - Ultustalfs)
Re)	Chan Buri (Cb)	Tha Chum Saeng series is transitional to Alluvial soils (Haplaquent)
Ub)	Klaeng (Kl)	Klaeng series soils may have laterite at < 50 cm depth
Ud)		
Pn)	Phan (Pn)	
	Pran Buri (Pr)	Tha Pran Buri series may be transitional to Red- Yellow Podzolic soils (Tropohrults)
	Pak Chong (Pc)	
	Klong Chaok (Kc)	Tha Nakhon Sawan series is transitional to Red Brown Earths (Rhodustalfs or Ultustalfs)
	Thad (Td)	Tha Thad series is transitional to Red Yellow Podzolic soils (Typochrult)
	Li (Li)	Tha Klong Chaok series is lateritic (Plinthochrults)
	Lat Ya (Ly) Tha Yang (Ty)	
Pp)	Chumpon (Cp)	
)	Sattahip (Sh) Huai Rong (Hg)	Part of the San Pa Tong series soils are Red Yellow Podzolic soils The Yang Ti[illegible] series is transitional to Red Yellow Latosols
	Tha Thai (Tt)	Tha Tha Thai series may be transitional to Reddish Brown Lateritic soils (Rhodochrults)
Yl)		

TABLE 2 PHYSIOG

PHYSIOGRAPHIC UNITS		A. Nakhon Sawan	B. Lop Buri
ALLUVIAL PLAINS	Marine deposits		Bang Len (Bl)
	Brackish water deposits		Bang Khen (Bn) Rangsit (Rs) Ongkarak (Ok)
	River and creek (fresh water) deposits	Tha Muang (Tm) Sapphaya (Sa) Chainat (Cn) Rat Buri (Rb) Yang Pong (Yp) Tha Taka (To)	Tha Muang (Tm) Sapphaya (Sa) Chainat (Cn) Rat Buri (Rb) Phimai (Pm) Khok Krathiam (Kk) Tha Taka (Ta)
BEACHES AND DUNES			
SEMIRECENT TERRACES	Marine and brackish water deposits		
	Lacustrine deposits	Baraphet (Bp) ? Lop Buri (Lb)	Ban Mi (Bm) Lop Buri (Lb) Chong Kae (Ck) ?
	River deposite	Kamphaeng Saen (Ks) Phet Buri (Pb) Nakhon Pathom (Np) Manoram (Mn) Saraburi (Sb) Ubon (Ub) Chum Saeng (Cs) Krak Phra (Kr)	Nakhon Pathom (Np) Manorom (Mn) Saraburi (Sb)
OLDER FILL TERRACES	Low terrace levels	Lampang (Lp) Sakon (Sk) San Pa Tong (Sp)	Hin Khang (Hk) Sakon (Sk) Satthahip (Sh) partim Phen (Pn) ? Phon Phi Sey (Pp) ?
	Middle terrace levels	Lat Ya (Ly) Takli (Tk) partim Pak Chong (Pc) partim	Takli (Tk) partim Pak Chong (Pc) partim
	High terrace levels		
STRATH TERRACES AND PENEPLAINS (Residuum and colluvium)		Takli (Tk) partim Pak Chong (Pc) partim Nakhon Sawan (Ns) partim Tha Yang (Ty) partim	Takli (Tk) partim Pak Chong (Pc) partim

2 PHYSIOGRAPHIC POSITION OF THE SOIL SER

STUDY AREAS

B. Lop Buri	C. Chiang Mai	D. Pran Buri	E. Khon Kaen	F. Chantab
Bang Len (Bl)		Tha Chin (Tc) Samut Prakan (Sm) Bang Kok (Bk) Bang Lamung (Lm)		Tha Chin (Tc) Samut Prakan Bang Lamung
Bang Khen (Bn) Rangsit (Rs) Ongkarak (Ok)		Cha-Am (Ca) Tha Khwang (Tq) Ongkarak (Ok)		Cha-Am (Ca) Tha Khwang Ongkarak (Ok)
Tha Muang (Tm) Sapphaya (Sa) Chainat (Cn) Rat Buri (Rb) Phimai (Pm) Khok Krathiam (Kk) Tha Tako (To)	Tha Muang (Tm) Sapphaya (Sa) Rat Buri (Rb) Phimai (Pm) Kalasin (Kn) Mae Khan (Mk) Tha Taka (To)		Chiang Mai (Cm) Rat Buri (Rb) Phimai (Pm) Kalasin (Kn) Si Thon (St)	Ban Khai (Bl) Phimai (Pm)
		Hua Hin (Hh)		Hua Hin (Hh) Rayong (Ry) Pattalung (Pt)
		Nong Kae (Nk) partim Sam Roi Yot (Sy)		
Ban Mi (Bm) Lop Buri (Lb) Chong Kae (Ck) ?				
Nakhon Pathom (Np) Manorom (Mn) Saraburi (Sb)	Hang Dong (Hd)	Pran Buri (Pr) Nakhon Pathom (Np)	possibly part of the Roi Et (Re) low phase	Pran Buri (Pr)
Hin Khang (Hk) Sakon (Sk) Sattahip (Sh) partim Phen (Pn) ? Phon Phi Say (Pp) ?	Lampang (Lp) Sakon (Sk) Phon Phi Say (Pp) San Pa Tong (Sp)	Nong Kae (Nk) partim Chon Buri (Cb) Sattahip (Sh)	Roi Et (Re) partim Ubon (Ub) partim Udon (Ud) Phen (Pn) partim	Chon Buri (Cb) Klaeng (Kl) Phen (Pn) Phatthaya (Py) Sattahip (Sh) Huai Pong (Hp) Lat Ya (Ly)
Takli (Tk) partim Pak Chong (Pc) partim	Lat Ya (Ly) Mae Rim (Mr) Mae Taeng (Mt)	? Siracha (Sr)	Roi Et (Re) partim Ubon (Ub) partim Phen (Pn) partim Korat (Kt) partim Nam Phong (Ng) Phon Phi Say (Pp) Yang Talat (Yl) partim Yang Talat (Yl) partim Yasothon (Yt)	Lat Ya (Ly) ?
Takli (Tk) partim Pak Chong (Pc) partim				Lat Ya (Ly) Chumpon (Cp) Khlong Chedi Trad (Td)

2

OIL SERIES IN THE MERS STUDY AREAS

	F. Chantaburi	Remarks
	Tha Chin (Tc) Samut Prakan (Sm) Bang Lamung (Lm)	The Tc, Sm and Bk soils form a sequence of tidal flat soils, characterized by deminishing salt content. The Bl soils are soils of less well drained marine back swamps. The Lm soils mostly are found in depressions between successive beaches.
	Cha-Am (Ca) Tha Khwang (Tq) Ongkarak (Ok)	Ca soils are soils of the prssent-clay tidal flats and mangrave swamps. In Tq soils, the surface layers are marine deposits; the subsoil is brackish water deposited. The Bn, Rs an Ok soils form a sequence of backswamp soils of increasing acidity.
	Ban Khai (Bi) Phimai (Pm)	The river levee - basin (backswamp) sequence in wider river plains is : Tm or Cm - Sa - Cn - Rb - Pm or Kk - with increasing finer texture, lower topography and deficient drainage. Ta, Mk and St soils are found in narrow creek valleys, with catchment areas, respectively influenced by limest rocks (mica-schist, biotite gneiss), and quartzitic terrace formations and/ar sandstone.
	Hua Hin (Hh) Rayong (Ry) Pattalung (Pt)	
		The lacustrine origin of the material of the Bp and Ck series is not certain.
i Et(Re)-	Pran Buri (Pr)	The river levee - basin sequence in larger semi-recent river terraces is : Ks - Pb - Np or Mn - Sb, with increasing finer texture, lower topography and deficient drainage.
	Chon Buri (Cb) Klaeng (Kl) Phen (Pn) Phatthaya (Py) Sattahip (Sh) partim Huai Pong (Hp) Lat Ya (Ly) partim	In the low terrace of northeastern Thailand (Khan Kaen study area), a lower (semi-recent?) and highe can frequently be observed. This subdivision is mostly not clear in other parts of the country.
	Lat Ya (Ly) partim ?	The separation between middle and high terrace is only distinct in northeastern Thailand. 3 The Sr and Yt show the same (fossil) soil formation; the terraces on which they occur may thus be of
	Lat Ya (Ly) partim Chumpon (Cp) Khlong Chack (Ck) Trad (Td)	Age correlation between the various strath terraces-peneplains and the fill terraces is mostly not possil that the strath terraces are of the same age as the middle terrace level.

STUDY AREAS

Remarks
ence of tidal flat soils, characterized by deminishing sc.. content. ained marine back swamps. pressions between successive beaches.
y tidal flats and mangrove swomps. marine deposits; the subsoil is brockish woter deposited. ence of backswamp toils of increasing acidity.
sequence in wider river plains is : Tm or Cm - Sa - Cn - Rb - Fm or Kk - Yp or Kn, pogrophy and deficient drainage. ow creek valleys, with cotchment areas, respectively influenced by limestone, micaceous nd quortzitic terroce formations ond/or sandstone.
al of the Bp and Ck series is not certain.
larger semi-recent river terraces, is : Ks - Pb - Np or Mn - Sb, with rophy and deficient drainage.
Thailand (Khon Kaen study oreo), a lower (semi-recent?) ond higher phase division is mostly not clear in other parts of the country.
high terrace is only distinct in northeastern Thailond.
soil) soil formation; the terraces on which they occur may thus be of the same oge.
s strath terraces - peneplains and the fill terraces is mostly not possible. However in some cases, it is fairly certain same age as the middle terrace level.

		Lop Buri (Lb)	Lop Buri (Lb) Chong Kae (Ck) ?
	River deposits	Kamphaeng Saen (Ks) Phet Buri (Pb) Nakhon Pathom (Np) Manorom (Mn) Saraburi (Sb) Ubon (Ub) Chum Saeng (Cs) Krok Phra (Kr)	Nakhon Pathom (Np) Manarom (Mn) Saraburi (Sb)
OLDER FILL TERRACES	Low terrace levels	Lampang (Lp) Sakon (Sk) Son Pa Tong (Sp)	Hin Khong (Hk) Sakon (Sk) Sattahip (Sh) partim Phen (Pn) ? Phon Phi Say (Pp) ?
	Middle terrace levels High terrace levels	Lat Ya (Ly) Takli (Tk) partim Pak Chong (Pc) partim	Takli (Tk) partim Pak Chong (Pc) partim
STRATH TERRACES AND PENEPLAINS (Residuum and colluvium)		Takli (Tk) partim Pak Chong (Pc) partim Nakhon Sawan (Ns) partim Tha Yang (Ty) partim	Takli (Tk) partim Pak Chong (Pc) partim
FOOTSLOPE AND LOW HILLS		Nakhon Sawan (Ns) partim Li (Li) Tha Yang (Ty) partim Pak Chong (Pc) coll. phase	Sattahip (Sh) partim Tha Yang (Ty)
VOLCANIC PLATEAU			
HIGH HILLS, MOUTAINS AND HIGH PLATEAU			

5

N

i (Lb) ae (Ck) ?				
Pathom (Np) n (Mn) (Sb)	Hang Dong (Hd)	Pran Buri (Pr) Nakhon Pathom (Np)	passibly part of the Roi Et (Re)-low phase	Pran Buri (Pr)
ong (Hk) (Sk) (Sh) partim Pn) ? hi Say (Pp) ?	Lampang (Lp) Sakan (Sk) Phon Phi Say (Pp) San Pa Tong (Sp)	Nong Kae (Nk) partim Chon Buri (Cb) Sattahip (Sh)	Roi Et (Re) partim Ubon (Ub) partim Udon (Ud) Phen (Pn) partim	Chon Buri (Cb) Klaeng (Kl) Phen (Pn) Phatthaya (Py) Sattahip (Sh) partim Huai Pong (Hp) Lat Ya (Ly) partim
Tk) partim ong (Pc) partim	Lat Ya (Ly) Mae Rim (Mr) Mae Taeng (Mt)	? Siracha (Sr)	Rai Et (Re) partim Ubon (Ub) partim Phen (Pn) partim Korat (Kt) partim Nam Phong (Ng) Phon Phi Say (Pp) Yang Talat (Yl) partim Yang Talat (Yl) partim Yasathon (Yt)	Lat Ya (Ly) partim ?
(Tk) partim hong (Pc) partim				Lat Ya (Ly) partim Chumpon (Cp) Khlong Chack (Ck) Trad (Td)
hip (Sh) partim ang (Ty)	Chumpon (Cp) Li (Li) Tha Yang (Ty) Nakhon Sawan (Ns) Pak Chong (Pc) coll phase	Nakhon Sawan (Ns) Tha Yang (Ty) Pak Chong (Pc) coll. phase		Sattahip (Sh) partim Lat Ya (Ly) partim Tha Yang (Ty)
				Tha Mai (T')

No individual series were indicated

Et(Rs)-	Pran Buri (Pr)	The river levee - basin sequence in larger semi - recent river terraces is : Ks - Pb - Np or Mn - Sb, with increasing finer texture, lower topography and deficient drainage.
	Chon Buri (Cb) Klaeng (Kl) Phen (Pn) Phatthaya (Py) Sattahip (Sh) partim Huai Pong (Hp) Lot Ya (Ly) partim	In the low terrace of northeastern Thailand (Khon Kaen study area), a lower (semi - recent?) and higher phase can frequently be observed. This subdivision is mostly not clear in other parts of the country.
	Lat Ya (Ly) partim ?	The separation between middle and high terrace is only distinct in northeastern Thailand. The Sr and Yi show the same (fossil) soil formation; the terraces on which they occur may thus be of the same
	Lat Ya (Ly) partim Chumpon (Cp) Khlong Chack (Ck) Trad (Td)	Age correlation between the various strath terraces - peneplains and the fill terraces is mostly not possible. Ha that the strath terraces are of the same age as the middle terrace level.
	Sattahip (Sh) partim Lat Ya (Ly) partim Tha Yang (Ty)	
	Tha Mai (Tl)	

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13 ABSTRACT

The study reported herein presents a summary of the methods and techniques used in the survey and correlates the various soil series with great soil groups and subgroups and physiographic position. The corresponding taxa of the new USDA soil classification system were also indicated. A summary is given of the geomorphologic relations between the various soil series. For each of the selected study areas, detailed descriptive reports accompanied by soil maps on a scale of 1:50,000 were prepared and included as Appendixes A through F to this report. Each appendix includes a general description of natural conditions in the study area as related to soil conditions, as well as a detailed description of the mapping units.

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14 KEY WORDS	LINK A		LINK B		LINK C	
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